Ecologically Relevant Streamflow Characteristics Across the United States

Ken Eng

Daren M. Carlisle (USGS)

David M. Wolock (USGS)

USGS science for a changing world

Background

- Prevalence of altered streams in US
  - Dams, land use, urbanization, etc.
  - Linked to impairment of ecological conditions.

- Previous studies used dozens to hundreds flow metrics and predictability not addressed.

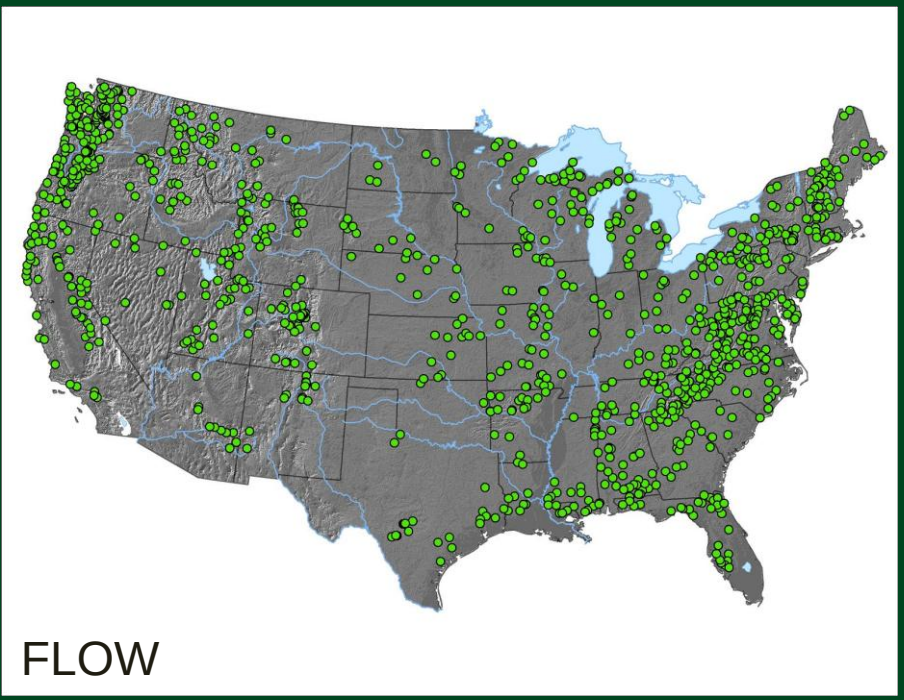
- Loose usage of term “ecologically relevant flow metric” (e.g., intuitive reasoning, programs).

Objectives

- Assess predictability of flow metrics at least disturbed basins.

- Ecologically relevant flow metrics – significant impairment fish & bugs across different regions.

Study Area

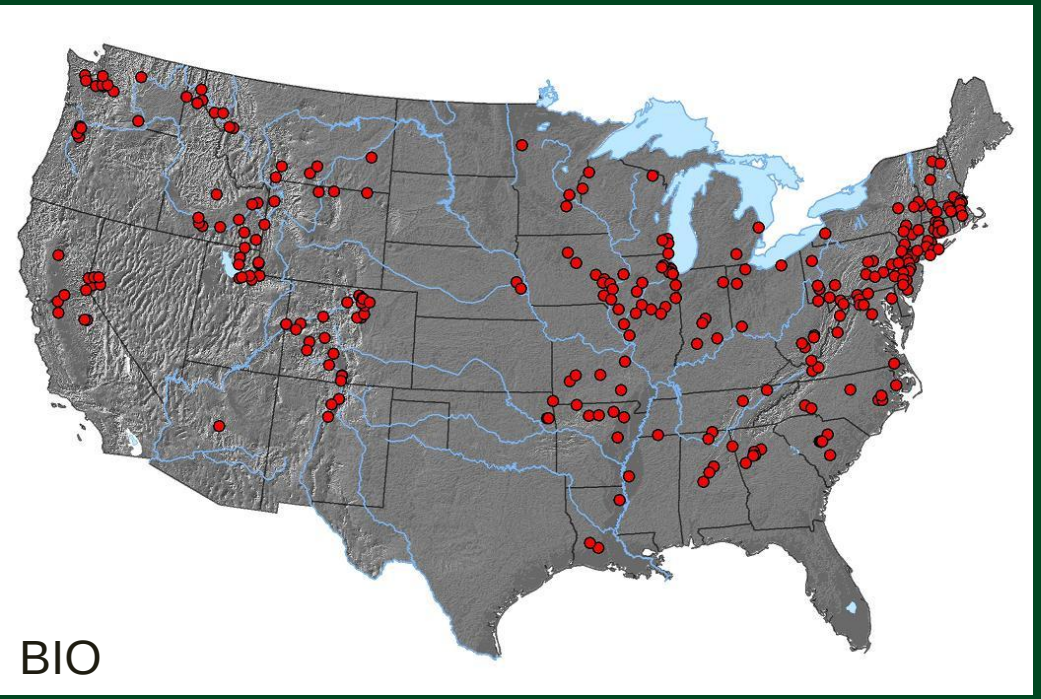


- 1,035 USGS gages
- Perennial conditions.

- Used to form models to predict flow metrics for natural (minimally disturbed) conditions.

USGS science for a changing world

Study Area



- 269 sites with macroinvertebrates and flow.
- 230 sites with fish and flow.

- LATER: Applied to sites (BIO) that have altered flows to quantify amount of alteration in flow metrics.

USGS science for a changing world

Identify Predictable Flow Metrics

- 858 flow metrics (daily flows).
- High, low, median, homogeneity, and misc. flow metrics.
- Random forest regressions:
  - Relates flow metrics and natural basin attributes.
  - Getting best models to predict flow metrics under natural conditions.

USGS science for a changing world

Identify Predictable Flow Metrics

- Criteria (accuracy and precision) at natural basins
  - E_{FM} = estimated flow metrics under natural conditions
  - O_{FM} = observed natural flow metric
  - Mean O_{FM}/E_{FM} >0.90 or <1.10 (+-10%)
  - Standard deviation O_{FM}/E_{FM} <=0.50

USGS science for a changing world

Findings

- Predictability of flow metrics at natural basins
  - 25% (226) of 858 flow metrics are predictable.
    - Low flows: Winter and Spring min, & total no low pulses (P10).
    - High flows: 1-day max, Spring max, & length of hi pulses (P90).
    - Homogeneity & Others: May skew & reversals.
  - Unpredictable flow metrics
    - 7-day min, Winter avg, P01, P10, P25, and several more low flow metrics).
    - Potential problem with relating to ecology.

NEXT:
What flow metrics are ecologically relevant?

USGS science for a changing world

Altered Flow Metric Data

- Degree of Alteration:

$$\frac{O_{FM}}{E_{FM}} = \frac{\text{Observed Flow Metric}}{\text{Estimated Natural Condition Flow Metric}}$$

- E_{FM} from random forest regressions on natural basins.

- O_{FM} are observed altered flow metrics at bio site.

Biological Data

- Percentage of native species expected to be found, O/E (≈ loss of native species).

- Simplified as a binary variable
  - "Impaired" = site O/E value < 90% of that of regional reference sites
  - "Unimpaired" = otherwise

Identify Ecologically Relevant Flow Metrics

- Identification:
  - Random forest classification models (interactions and covariates).
  - Relate O_{FM}/E_{FM} and 7 covariates (6 physical-chemical measures + land use) to O/E biological values (binary).
  - Ranked lists of mean importance.
  - Using only predictable flow metrics. (Check all flow metrics to see if noisy flow metric relationship to bio is strong enough get over the noise)

USGS science for a changing world

Identify Ecologically Relevant Flow Metrics

- Impairment of the fish community:

  decreased high and spring flows, and increased winter minimum flows.

- Impairment of the macroinvertebrate community:

  - Increasing urban land cover (>10%)

  - decreased high flows in spring and annual maximum magnitude.

- Check on all flow metrics consistent.

USGS science for a changing world

Summary of Findings

- 25% out of 858 flow metrics are predictable at least disturbed basins.
  - Mixture of low, high, median, homogeneity, and others.
  - A lot were not predictable (low flow ones).

- High, spring, and winter flows significantly impair fish and bug communities.
  - Some flow metrics relevant across many different regions of the US.
  - Unpredictable flow metrics could be ecologically relevant at local/subregional scales.

USGS science for a changing world

Summary of Findings

- "Ecologically relevant flow metrics" – flow metrics that are strongly associated with biological impairment.

Questions